diverse, and is constant in its diversity; and there are other differences which, though eluding attention at first, are really very marked.

DESCRIPTION OF PLATE IV.

All the shells are considerably enlarged; the apices of each still more magnified.

Figs. 1, 1*a*. *Cerithiopsis tubercularis*, Mont.
2, 2*a*. „ *pulchella*, Jeffr.
3, 3*a*. „ *costulata*, Möller.
4, 4*a*. „ *Barleei*, Jeffr.
5, 5*a*. „ *fayalensis*, Wats., n. sp.
6, 6*a*. „ *tiara*, Wats., n. sp.
8, 8*a*. „ *diadema*, Wats., n. sp.
9, 9*a*. „ *atalaya*, Wats., n. sp.
10, 10*a*. „ *Metaxæ*, Chiaje.

The above figures correspond with the numbers in the foregoing description, but No. 7, *C. Clarkii*, is not here figured, having already been illustrated in Forbes and Hanley, *l. c.*

On the Anatomy of the Ambulacra of the Recent *Diadematidæ*.

By Prof. P. Martin Duncan, V.P. Linn. Soc., F.R.S., &c.

[Read 5th March, 1885.]

(Plate V.)

Contents.

I. Introduction.
II. The ambulacra of *Diadema sètosum*.
III. The structure of the edges of the plates (interambulacral and ambulacral).
IV. The ambulacra of *Echinothrix Desori* and *E. calamaris*.
V. The ambulacra of *Astropyga radiata* and *A. pulvinata*.
VI. The ambulacra of *Centrostephanus*.
VII. The ambulacra of *Micropyga tuberculata*.
VIII. The ambulacra of *Aspidodiadema microtuberculatum*, Agass.

I. Introduction.

In a communication on some hitherto unobserved structures of the Arbaciadæ, which was read before this Society by Mr. Percy Sladen and myself on February 5, 1885, we stated that the classificatory part of our essay would be given subsequently.

At that time we were not aware of the bearing of some of the structures of the test of the Diadematidæ on the general question

of the classification of the group of Echinoidea with triple pairs of pores; but probably the readers of this communication, which relates to the genera *Diadema*, *Echinothrix*, *Centrostephanus*, *Astropyga*, *Micropya*, and *Aspidodiadema*, will consider, with us, that it should appear before the second part of the essay by Mr. Percy Sladen and myself.

II. Genus Diadema, *Gray*. Diadema setosum, *Gray*.

This well-known form usually breaks anywhere than at the sutures which separate the plates of the test. The test is thin, and is well covered with a semi-leathery tissue when dry, and the plates have much connective tissue between them.

Tests were carefully denuded by means of chloride of lime and exposure to the weather, and there was no difficulty in then separating any plates except the triplets of the compound ambulacral plates. Reagents, such as benzole, render the lines of the sutures of those firmly united plates visible.

The Ambulacra.—Taking a tubercle-bearing plate at the ambitus, the triplet of large pores, the large perforate and crenulate tubercle, and a very small, yet perfect, tubercle close to the median suture of the compound plate are readily noticed (Plate V. fig. 3).

The pairs of pores are in slight curves, and their direction is rather oblique. The pairs are distant, their peripodia do not touch, and there are often one or more minute tubercles, or granules, between them.

The pores follow the rule regarding the position of triplets, and the lowest or adoral pair is close to the actinal edge of the compound plate and nearer to the median line of the ambulacrum than the other pairs. The second pair is, as usual, the most external of the three, and the first pair is more internal than the second, and yet not so much so as the third pair.

On examining an ambulacrum from within, it was found that the arrangement of the triplets of the compound plates is not the same as that seen in such Triplechinidæ as *Strongylocentrotus*, for the second plate of every combination is the largest of the three, and indeed it composes much of the compound plate. In the poriferous part of a compound plate, the sutures between the first and second, and between the second and third plates are not horizontal, and as they approach the position of the tubercle they converge slightly, so that the second or middle plate becomes nipped

in there and low. Thence the sutures gradually diverge and reach the median or vertical suture of the compound plate at points very distant one from the other. One suture, that between the first and second plates of the triplet, reaches the inner or median edge of the compound plate, close to and below its abactinal angle (Plate V. figs. 1 and 2). The other suture, or that between the second and third plates, attains the median edge close to and above the actinal angle of the compound plate.

As both of these sutures reach the median line, all the plates of the triplet are primaries, and there is no demi plate.

In consequence of the divergence of the sutures internally to the mamelon of the compound plate, the second, or central plate, is the largest, and carries the greater part of the tubercle; the other two plates are pushed adorally and aborally and have suffered compression from above downwards during growth, and they are low plates, except where they expand in height at the region of the tubercle. (Fig. 3.)

The triple combination therefore consists of a long low primary, of a long and internally expanded and tall middle primary, and of a third plate resembling the first plate, more or less.

In the figure (Plate V. fig. 1), it will be observed that the line of suture between the first and second plates does not pass from the adoral pore of the first pair; this is owing to the growth of the plates in height. The corresponding defect in the instance of the adoral pore of the other pairs is due to the same cause; but originally the lines of suture were, as is usual in all *Echini*, and as is indicated on fig. 2.

Throughout the ambulacra the compound plates present variation in their height and breadth, but the succession of the three primaries of the triplets is always the same. The second plate is never blocked out from the median line by a union of the sutures between the first and the third plates.

Usually the sutures cannot be traced on the outside of the compound plate, and the sides of the tubercles are free from any markings; but the application of benzole will sometimes indicate the lines of junction of the plates, and then the mamelon will be seen to lie between the sutures and to belong to the second plate. (Plate V. fig. 3.)

The distinction between the arrangement of the triplets in *Diadema* and the Arbaciadæ is evident, for the first and third plates of the compound plates of the ambulacra of *Diadema*

never become demi plates, but remain primaries *. The cause of the persistence of the low primaries in *Diadema* relates to the method and the rapidity of the growth of the tubercle-bearing second plate, as well as to the amount of downward pressure developed during the growth of the new plates at the radial end of the ambulacra. The plates are all primaries there. (Plate V. fig. 4, 4 *a*.)

In the communication by Mr. Percy Sladen and myself, already alluded to †, we noticed especially the peculiar growth of some plates not far from the radial plate in *Cœlopleurus Sindensis*, nobis. It was noticed that although, in specimens of that species, the triplets of the tubercle-bearing plates at the ambitus were as is usual in the genus, yet more abactinally, and where the downward growth-pressure was not assisted by the expansive growth of the second or tubercle-bearing plate, the adoral and aboral plates of the triplet were not forced to become demi plates: they still remained as long and low primaries. This state of things is exceptional in the Arbaciadæ, but it is normal in the genus *Diadema*.

III. The Structure of the Edges of the Plates at the Sutures.

The Vertical Sutural Edges between the Ambulacra and the Interradia.—The line of suturing is a series of convex triplet-plate ends received into corresponding concavities in the interradial plates. On the exposed edges of both the ambulacral and interradial plates there is a thin, and rather solid, layer at the inner part of the section, and a corresponding structure at the outer or superficial part; but all the intermediate thickness is occupied by a number of excessively thin, straight or wavy, distinct, and long laminæ. They are separated by similarly shaped spaces, which are rarely crossed by any offshoots of the lamellar structure. The lamellæ conform to the windings of the sutural surfaces, and those of one compound plate, or of an interradial plate, are continuous.

The laminæ are not continued across the sutures, and it is evident that the interspaces were once occupied by connective

* Quite at the peristomial edge a plate may become a demi.

† Journ. Linn. Soc., Zool. vol. xix. p. 36, pl. i. fig. 9. (The figures 6 and 9 have been misplaced on this plate; but although on p. 36 and p. 57 the reference is to fig. 6, the drawing is marked 9.)

tissue. The coarsely laminated condition of the plates is not found far inwards, for they are comparatively solid centrally; but it appears that the primitive state of these, and indeed of all the plates of the test, was finely laminate.

The Sutural Edges between the Compound Plates of the Ambulacra.—No special structure is seen, and the edges of the plates are nearly solid looking, the trace of lamination being absent or very slight. But there is some overlapping of the outer surface of one plate over the corresponding surface of the next, and especially where there is a minute tubercle close to the outer edge of the suture. The base of the tubercle overlaps a planed-off surface belonging to the next plate. Moreover, when there are large granules or small tubercles on the successive plates, there is a corresponding overlap.

The Edges of the Median or Vertical Sutures of the Ambulacra.—The small tubercle at the point of each compound plate at the median line plays an important part in this zigzag of sutures.

As the point of one plate is received into the re-entering angle of the junction of two successive plates, and the small tubercle is on the point, so there is beneath it a deeply cut-away or concave surface which corresponds to a projection on the opposed plate. Over this slight projection is, of course, the overlapping tubercle-base, and usually there is a little bevelling there of the angle of the plates of the opposite zone. The faces of the edges of the median sutures are finely laminated, but not so coarsely as those of the sutures between the ambulacra and the interradia.

The Median Sutures of the Interradia.—These are best examined from within the test. The zigzag, or the median or vertical line of suture of an interradium, is very distinct within the test. But the edges of the plates at the median suture are not in a straight line converging at angles, and they are evidently not united along planes perpendicular to the surface of the test. The zigzag is in slight curves, and the adoral edge of the coronal plates at the median suture is curved adorally, and underlaps (in the proper position of the test) a corresponding depression on the edge of the aboral part of the suture of the actinally placed plate.

This underlap is very decided in some places, and when the plates are separated, the lamellar expansion of the adoral part of the suture becomes conspicuous. This lamella is a prolongation of the inner layer of the test.

The opposed edges of both the adoral and aboral sutures are marked by well-developed, distinct, and more or less numerous,

parallel laminæ, separated by corresponding spaces. The laminæ of one edge fit into the spaces of the other and opposed plate, and there is much uniting connective tissue there, in the living form.

Above the ambitus, where the coronal plates are broad and low, the following points may be observed at the median suture.

On the outside of the test, the aboral sutural line is longer than the adoral. Seen from within the test, the adoral sutural edge presents a convex surface, and the aboral a slight concavity; moreover, the edge of the adoral suture slopes from within outwards, and the aboral face slopes in the opposite direction.

The adoral edge has on it the projecting lamella, which is continuous with the inner layer of the test, and also three distinct parallel laminæ, which are stout, long, and separated by corresponding spaces. Externally to these is the outer lamella of the test.

On the aboral edge there are two parallel laminæ with intervening spaces, and these laminæ are distinct from the thin outer and inner lamellæ of the test.

In some plates the number of laminæ may be great, but the example given is a very common one. Sometimes the edges of the laminæ are crenulate, and the amount of inward and outward slope of the face of the sutures varies.

The nature of the vertical suture changes towards the apex, where the plates are high in comparison with their breadth.

The adoral edge, which is the longest, has the inner lamella projecting as a stout process as thick as the narrow, curved, and sharp aboral edge. But the adoral edge has a decided groove externally to the inward overlapping process. It is into this groove that the aboral process of the actinally placed plate fits.

Hence at the apex the vertical sutures of the interradia are characterized by decided underlap and elongated dove-tailing.

The Transverse Sutures of the Interradial Plates.—As a rule, the plates are obliquely placed, and whether they are so or not, the adoral edges are more or less convex actinally, but the aboral edges are the reverse. Near the peristome the faces of the sutures on the opposed plates are nearly flat, or there may be a very slight projection along the middle of the adoral edge.

The edge looks homogeneous, and it is only near to the lateral sutures of each plate that a fine lamination presents itself, the commencement of the sutural development already noticed.

Every now and then perfectly distinct groups of knobs and

corresponding sockets may be seen near the ambulacral and median ends of the interradial plates. They are especially visible close to the sutures which unite the auricles to the interradia.

The knobs and the sockets are evidently modifications of the parallel lines of laminæ, but although their existence cannot be ignored, it cannot be advanced that they contribute to the strength of the suturing. Finally, it appears that very visible grooving and corresponding ridging of the horizontal edges of the interambulacral plates occurs when the tubercles are rather close to the adoral edge of a plate. The base of the tubercle forms a kind of overlap, and this is very significant when other Diadematidæ are considered.

IV. Genus Echinothrix, *Peters*, *Monatsb. Akad. Berlin*, 1854, p. 101.

The critical description of this genus and its comparison with the other Diadematidæ may be read in the 'Revision of the Echini,' by A. Agassiz, p. 413. Both Peters and A. Agassiz state that the structure of the ambulacra in this genus differs from that seen in the genera *Diadema* and *Astropyga*. The ambulacra differ from those of the last-mentioned genera "in having many vertical rows of very small tubercles." The compound plates are numerous in *Echinothrix*, and the number of the pairs of pores in a given vertical space is greater than in *Diadema*. Consequently there is not the room for large primary and big secondary tubercles in the ambulacra of *Echinothrix* as there is in *Diadema*. The triplets of *Echinothrix* are close, and the vertical dimension of the combined plates is small. External appearances would lead to the belief that the arrangement of the sutures of the ambulacra is like that of such Triplechinidæ as *Strongylocentrotus*, as drawn by Lovén, or that it would resemble the diagram drawn of the sutures of the triplet of *Diadema* by A. Agassiz; but a careful examination shows that the plates are arranged after the type of *Diadema*, as explained in a former page, there being no demi plate in the compound plate,—all the plates, however low they may be, from crowding and growth-pressure, being primaries. (Plate V. fig. 6 and 6*a*.)

The specimen of *Echinothrix Desori*, Agass., which I have used in this research was large and well grown, and I have chosen one of the plates, about the tenth from the peristome, which has only

one tubercle upon it, for study, besides a number of unseparated compound plates from the ambitus to the apex.

The Ambulacral Compound Tubercle-bearing Plate, from the inside of the Test after the application of Benzole.—Each plate is much broader than high, and is composed of three plates, the triplet of pairs of pores being arranged as in *Diadema*. The sutures of the poriferous part of the plates are nearly parallel, but those between the first and second and the second and third plates approach just internally to their adoral pores, but do not unite. Thence the sutures diverge and reach the median line, or the vertical suture of the compound plate close to the actinal and abactinal angle of that part of the plate, respectively. Hence the first and third plates, although primaries, are often low, close to the median line, whilst the second plate is large and high there. The reverse of this is seen internally to the adoral pores of the triple plates, for there the second plate is low and the first and the third are correspondingly high. (Plate V. figs. 6, 6 *a*, and 7.)

It is difficult to trace the line of the sutures on the outside of the test, and over the tubercles; but as the benzole dries, the sutures may be seen crossing over or rather passing along the breadth of the plate, approaching one another on the tubercle, having the mamelon between them, and then one passes towards the abactinal and the other towards the actinal angle of the median suture of the compound plate. (Plate V. fig. 6.)

The regular distribution of the pairs of pores, from close to the apex to near the peristome, is very striking when viewed from within the test. The lines of the pairs are very oblique, and the third pair of pores of the triplets is larger than the others, and the adoral pore of this pair is always very large. It is nearer the median line of the ambulacrum than the other pores. As the series of these third pairs are numerous, the large pores just mentioned form definite lines on either side of the median suture and at some distance from it. (Plate V. fig. 7.)

The plates forming the compound plates close to the radial plate are of course small and low, but they are nearly or quite of equal size. The sutural lines pass directly towards the median line, and without any bending, so that the three plates are almost rectangular in shape and all reach the median line. This is the simplest possible arrangement of triplets in a compound plate. A little way down the ambulacrum, the pressure from the coming in of new primaries at the radial plate and the expansive growth

of the inner part of the compound plate where the tubercle is going to be, determine the diminution in the height of the first and third plates, close to the median line.

The Peristomial Region of the Ambulacra.—The character of the triplets gradually alters from a little distance from the ambitus actinally. At a distance from the peristome corresponding to the sixth interradial plate, the ambulacral compound plates suffer from slight crowding from above downwards, and begin to widen, so that the pairs of pores gradually become more and more distant from the interradial sutures. (Plate V. fig. 8.) Instead of there being three plates to each compound plate at the ambulacro-interradial suture, there are only two, and they belong to the first and second plates of the triplet, for the exclusion of the third plate occurs gradually, its external part becoming smaller and smaller in the few triple combinations which are placed near the peristome.

Taking the three compound plates which are in relation to the fifth interradial plate from the peristome, as our example, it will be noticed that the peripodium of plate 2 of the abactinal compound plate is so closely placed above that of plate 3, that there can hardly be room for the extension of this last to the interradial suture. On cleaning the test within, and applying benzole, the absence of the third plate at the interradial edge is very evident (fig. 8), and it is seen that the compound plate is made up there of plates 1 and 2 only. The edge of the first plate at the ambulacro-interradial suture is not as high as that of the second plate. On carrying the eye along the transverse suture between the compound plate under consideration and that placed adorally, the outer edge of the third plate will be seen as an angular process, which terminates slightly externally to the aboral pore of the third pair.

The first plate of this triplet (Plate V. fig. 8) is bounded abactinally by the transverse suture between it and the plate immediately above, and which is the third plate of the triple combination placed abactinally. The external limit of the plate is a low curved edge at the interradial suture. The actinal boundary is a suture which passes from the adoral part of the curved edge just mentioned, towards the median line of the ambulacrum, adorally to the outer pore of the pair and then into the inner or adoral pore. Thence the suture passes inwards and slightly aborally, to reach the median or vertical suture of the compound

plate, not far from the aboral angle. This direction is that of the suture of all the first plates of the triplets of the test placed at and near the ambitus.

The second plate is higher than the first at the interradial suture, and is much the larger at the median line. Its abactinal limit is the line of suture which separates it from the first plate, and which has just been described. Its adoral limit is a small part of the transverse suture between the compound plate under consideration and that placed actinally. Then a line of suture commences and passes from the transverse suture, aborally and inwards with a low curved path, to reach the inner pore of the plate number two. Thence the direction of the suture is towards the median line, and slightly adorally, so that the vertical suture is attained just aborally to the actinal angle of the compound plate (fig. 8, I. 2).

The third plate is much the smaller of the three: it includes the most inwardly situated pair of pores of the triplet, and it reaches the median line, being placed there adorally to the suture just described; but the plate does not come in contact with the interradial suture. The actinal limit of this little plate is the transverse suture between the two compound plates.

The next compound plate (II.) closely resembles that just described, but it is rather higher at the median line. The arrangement of the sutures of the triplets is identical. The pairs of pores are, however, more remote from the interradial suture than those of the compound plate already described. The obliquity of the pores of the pairs in some instances prevents the satisfactory use of the term adoral to indicate the inner pore of a pair, for these may be placed aborally to the other series.

Compound plate the third (III.) has the details of those already described, but it is rather lower at the median line than the second compound plate. Hence it is high externally, where, however, there are only two plates of the triplet visible. Of these the first is decidedly the smaller. The third plate is small, is well removed from the interradial suture, and it reaches the median line, resembling the third plates of the compound plates already noticed.

Further changes have been produced by pressure and growth in the more actinally placed compound plates which are in relation to the interradial plate situated actinally to the last mentioned.

Still nearer the peristome the compound plates diminish in vertical dimensions, and the pairs of pores become very remote from the interradial suture on account of the presence of the ascending process of the auricule; but although the arrangement of the triplets is a crowded one, the triplets of every compound plate can be distinguished, there being no accessory plates.

The principal alteration in the arrangement of the triplets is not externally, but near the median line. The first plate of the combination (plate IV. of the series) is low, and as it approaches the median line it becomes lower, and finally it does not reach the median line. It is a low demi plate. The second plate comprises the whole, or nearly the whole, of the expansion of the plate at the median line. The third plate is small, and sometimes it may reach the adoral angle of the median suture, but with increasing crowding it is shut off from it as well as from the outer edge of the compound plate. (Fig. 5, x' is the line of the auricule.)

The characteristic arrangement of the triplets in this species, and probably it is generic, is that of small, close, low, and more or less rectangular primaries near the radial plate. More actinally the first and third plates of each triplet become low broad primaries, having their smallest height at the median line.

Then below the ambitus the third plate is crushed out externally at the interradial sutural edge. Still more adorally the first plate becomes lower at both ends, and finally it is excluded at the median line and becomes a demi plate in the ordinary acceptation of the term. In no case is there an arrangement as in *Strongylocentrotus*.

In *Diadema* this crowding out of the third plate does not occur, but close to the peristome the first and the third plates barely reach the median line, and are in one or two places demi plates.

The Median Suture of the Ambulacra.—The line of this zigzag is not composed of straight lines forming a succession of angles at their points of union or contact.

The line of suture is marked by a series of symmetrical curves, and thus where there might have been an angle at the median end of a coronal plate there is a convex process fitting into a corresponding concave line between the two opposed plates. (Pl. V. figs. 7 & 8.)

It is perfectly evident that the junction of the edges of the plates along the median line is not by simple apposition along

a plane perpendicular to the test, but that there is underlap of one series of edges, and overlap of others.

In *Echinothrix calamaris* the same structures occur as in *E. Desori*.

V. Astropyga, *Gray*, 1825.

This genus has species with the ambulacra projecting, and ornamented with large tubercles similar to those of the interradia. The pores are disposed in triple pairs.

The shape of the tubercles is rather like that of those of *Cœlopleurus*, and there is a bare median space near the apex in both genera.

The definition of the genus is given in Dujardin et Hupé, Hist. Nat. des Zooph. Échinodermes, Paris, 1862, p. 506, copied from Desor, Synopsis, p. 83. Each of these authors states that the distinction between *Astropyga* and *Diadema* consists in the former having the pores in triple pairs, whilst the latter has them disposed in simple pairs, but forming arcs and undulating zones around the ambulacral tubercles.

In the 'Revision of the Echini' by A. Agassiz, the genus is considered critically (p. 417). It is noticed that the tubercles of both areas are perforate and crenulate, and that the poriferous zone of the ambulacra is broader than in *Diadema*, and nearly as broad as the median ambulacral space. The pores are arranged in four irregular vertical rows forming steps of pores of three and one pair. In explaining the characters of *Astropyga pulvinata*, A. Agassiz observes that the ambulacra have the vertical rows of primary tubercles distant, frequently only every other plate carrying a primary, the opposite being only a secondary.

Reference is made to the general appearance of the ambulacra of *A. radiata* on page 421 of the 'Revision.'

The genus is very critically considered in the Report on the Echinoidea, 'Challenger' Expedition, p. 72, under the Echinothuridæ, and there are some important illustrations on plate x *a*. figs. 8 & 9.

Although the minute construction of the ambulacra is not considered, there are important observations on the division of the coronal plates above the ambitus, and the lapping of the transverse sutures of the areas. The following statement relates to a part of these researches in the anatomy of the test. "The lapping of the coronal plates in the Echinothuridæ is not so

absolutely a characteristic feature of the family as has been supposed. It exists already well developed in *Astropyga*, but with the important difference that the overlapping of the plates is in the same direction in both areas. The lower edge of the plate passes under the upper edge of the preceding plate" (*l. c.* p. 71). Put in other words, this means that the adoral edge of a coronal plate slopes from the outer surface inwards, in an actinal direction, and that the aboral edge slopes from within outwards in the abactinal direction.

The Ambulacra of Astropyga radiata.—The tubercles are large, perforate and slightly crenulate, and the base of the boss is wide and flattened out. The mamelon is small in relation to the size of the rest of the structure. At the part chosen for illustration (Pl. V. fig. 9), the great tubercle-bearing plate is apparently followed, apically, by a smaller one carrying a small tubercle, which is placed nearer the pores than the large tubercle. Seen from within the test, the position of the large tubercles is shown by a circular depression (fig. 10); and when the clearing agent is applied, it becomes evident that the large tubercle and the small tubercle are not on separate geometrical plates. The large tubercle as well as the smaller are really in relation with one huge compound plate; and the division of this plate into two is arbitrary, for the transverse dividing line between the two plates either abuts against the salient angle of the zigzag in the median line or close to it. Both plates, together with their aggregate of six component plates, are included in one geometrical, compound plate (Pl. V. figs. 9 & 10). It is best for the purpose of description to consider the great plate as composed of two, each one being made up of a triplet of pore-bearing plates. The edge of the poriferous plates at the interradial suture externally is very irregular, and some pores are quite out of the line (Pl. V. fig. 9). The three pairs and the apparently additional fourth are well seen in relation, but the fourth pair of pores is really the lowest of the triplet of the upper part of the combination. Seen from within, the arrangement of the pairs is very easily understood, especially after the study of *Diadema* and *Echinothrix*.

The illustration, Pl. V. fig. 10, is a diagram founded on magnified views of three great and geometrical plates; and is nearly true. It would be quite so were the effects of the bases of the tubercles on the inside of the test shown, but that would complicate the sutural lines.

In the illustration (fig. 10), the first great plate, A, consists of two sets of triplets. It carries a large tubercle, the concavity of which is seen on the plate, from within the test. The pairs of pores are in a group of three as in *Diadema*; the pores of the third plate are larger than those of the others, and the adoral pore is nearer the vertical suture than any of the others. The arrangement and the shape of the sutures between the triplets are on the type of *Diadema* and *Echinothrix*; but there is this difference, that instead of the first and the third plates suffering from the pressure of growth, the second plate is affected, and so much so that the other plates nearly meet at about the concavity for the tubercle, before their sutures diverge to reach the vertical suture. In this instance there is clearly a very narrow space between the adoral suture of the single first plate and the aboral suture of the third plate of the combination. The three plates are therefore primaries, and there is no demi plate in the combination. The adoral pore of plate 3 is on the transverse line of suture between the first and second sets of triplets of the great plate A. This line reaches the vertical suture adorally to the salient angle.

The first plate of the next triplet (2) is large, and it stretches over to the median line, which it reaches by a narrow termination; for the second plate, also a primary, expands there as well as the third plate. The expansion of the third plate, towards the median line, is considerable, and the result is to push the other plates of the triplet abactinally. There is no tubercle on this part of the great plate A, but the sutures which limit the first and second plates of the triplet nearly come in contact at the spot where a tubercle might have been. The suture placed adorally to the third plate limits the great plate A actinally; and its direction, in the main transverse, is slightly abactinally and towards the median line, for the expansion of the base of the tubercle on the next set of triplets pushes the suture upwards and towards the median line.

The great plate B is made up exactly after the plan of plate A, with this exception. The first plate of its second set of triplets (4, 1) does not reach the median line, being crowded out by the increased size of the second and third plates; so that the second plate is a primary much nipped-in at the position of the defective tubercle, and sufficiently expanded at the vertical suture to form the aboral half of the surface there, and also to reach the transverse suture between the two sets of triplets of

the great plate. The third plate of the triplet is large, and intrudes much on the space which is occupied by a second plate in compound plates placed higher up in the test.

The next great plate, C, differs in detail from the others. The first set of triplets (5) is without a tubercle, and the first of the plates is a long and low primary, with the adoral suture almost transversely placed so that a small portion of the median suture is in contact with the plate. The second plate occupies all the rest of the surface of the compound plate towards the median line, for the third plate is a demi plate. The second set of triplets (6) has a tubercle on it, and the direction of the sutures and the shape of the plates are the same as those of the first set of triplets of the great plate A.

On studying the ambulacra from the outside, but little can be learned regarding the shape of the plates of the triplets; but it is evident that the extremely close sutures noticed from within are more separated externally. The great plate C was rendered sufficiently permeable by light to trace the sutural lines, and some interesting points became evident (Pl. V. fig. 9).

Commencing with plate 1 of the aboral triplet, its shape corresponds with that noticed from within; the adoral suture crosses a large secondary and a smaller tubercle to reach the median line. Plate 2 extends beyond plate 3, towards the interradium, and its adoral suture curves at first abactinally, so as to touch the boss of the larger of the secondary tubercles, and then actinally. It then slopes to the aboral edge of the great tubercle of the next set of triplets, conforms to it, and reaches the transverse suture placed between the first and second set of triplets.

The third plate of this first set of triplets does not appear to belong to it, but to make up a plate of the second set. Nevertheless the plate is part of the first set, and the transverse suture of the half great plate limits it adorally. It is a demi plate, for it does not touch the median line.

The structure of the outside of the plate is rendered difficult of comprehension, because the great tubercle on the second set of triplets has grown so as to overlap and cover much of the third plate of the first set.

Plate 1 of the second set of triplets is a long low primary with its adoral suture crossing the aboral shoulder of the ridge at the base of the mamelon, and reaching the median line just adorally to the junction of the upper and lower triplets.

Plate 2 is a primary, comprising the mamelon and much of the base of the boss of the tubercle, and a large part of the surface at the median suture.

The plate 3 is a well developed primary which pushes plate 2 abactinally, and forms a part of the boss of the tubercle and also of a small part of the compound plate near the median line.

Astropyga pulvinata, Agass.—The details of the ambulacra of this species resemble those of *Astropyga radiata*, allowance being made for the difference in the dimensions of the tubercles in the two species.

The lapping of the coronal plates of the interradia is well seen in these forms; and the underlap of the aboral edge of the interradial plates at the vertical suture, by a thin process of the adoral edge of the abactinally placed plate, is distinct.

I have failed to notice the division of the interradial plate above the ambitus, described by A. Agassiz, in both species.

It will have been noticed that whilst the triplets of *Astropyga* are arranged, not after the type of the Triplechinidæ, but after that of *Diadema*, they differ from those of the last-named genus by being here and there made into demi plates, not, however, after the type of *Strongylocentrotus*, but rather after that of *Cœlopleurus*.

The union of the two sets of triplets in one great plate is very remarkable.

VI. Genus Centrostephanus, *Peters*, 1855.

A. Agassiz appears to consider this genus in the light of a subgenus of *Diadema*, for the word *Diadema* is placed in brackets before the generic term in the 'Revision.' Certainly the external resemblances of *Diadema* and the genus are great, and the presence of ten buccal plates with spines and pedicellariæ, the principal peculiarity of *Centrostephanus*, is only subgeneric.

The only specimen that I have seen shows that the ambulacra have the Diadematid character.

VII. Genus Micropyga, *A. Agassiz*, 1879.

Micropyga tuberculata, A. Agassiz, is fully described in the Report on the 'Challenger' Echinoidea, p. 68, pl. vii.

The following are the descriptions given of the ambulacra:—

"In the ambulacral areas the primary tubercles, arranged in only two vertical rows, increase regularly in size towards the ambitus, where they, as well as the interambulacral tubercles, are largest, and while occupying there nearly the whole of the ambulacral plates between the poriferous zones, become reduced on the abactinal surface to small secondary tubercles placed in the centre of the plates, which carry, besides, a few small miliaries or granules, occurring irregularly on the plates."

"The poriferous zone is of nearly uniform width, from the actinal edge to the apical system. There is no tendency to expansion of the poriferous zone at the actinostome." It had been noticed in dealing with the generic details, that "the poriferous zone is narrow, the pores are in pairs arranged in two vertical rows."

After studying the ambulacra of two dry specimens at the British Museum, I am able to add to this description. At the ambitus, the non-crenulate but perforated large tubercles are on alternate plates of the same ambulacral zone, the intermediate plates are smaller and carry from one to three large granules. Towards the apex there is a tubercle on every plate, and one is larger than the other. Near the radial plate the crowding of the ambulacral plates soon begins to be seen; and in the specimens examined there is, on the contrary, a simple single row of pairs of pores close to the peristome. There is no crowding there whatever.

As A. Agassiz has so well shown, the pairs of pores present a remarkable appearance in being placed nearly throughout the zones in two rows—an outer and an inner, and close together. See the drawings on pl. vii. figs. 4 & 5, 'Challenger' Report.

In order to examine the meaning of these two rows, which at first would seem to have no relation to series of triplets, part of ambulacrum II, near the ambitus, but above it, was chosen. It became evident, after the application of benzole, that every compound ambulacral plate is in relation with three of the pairs of pores; and that whilst the tubercle-bearing or larger plate has two pairs of the outer row of pores and one pair of the inner row associated with it, the plate immediately actinally, and which has not a large tubercle, has two pairs of the inner row and one pair of the outer row connected with its component plates. (Pl. V. fig. 11.)

The ambulacral plates are, on the whole, low and broad, and, except close to the apex and peristome, are compound plates, each being made up of three plates, of which the aboral and adoral, or Nos. 1 and 3, are small, low, and demi plates; and the central, or No. 2, is a primary plate expanded towards the median line, supporting the tubercle or the granules, and very low and sometimes almost linear, towards the interradial or poriferous extremity.

The drawing on Plate V. fig. 11, is slightly diagrammatic, and it explains the relative position and the shapes of the triplets of three consecutive compound plates. The upper compound plate has two pairs of the outer row of pores, and they correspond with the plates 1 and 3, which are demi plates, not reaching the median line of the ambulacrum. It has also one pair of the inner row of pores on plate 2, which is almost linear in form externally where it is crowded in between plates 1 and 2, and large towards the vertical suture, which limits it entirely at the median line of the ambulacrum. This plate is then a primary. The plate 1 becomes a demi plate, because the suture at its adoral edge, after passing actinally to the outer pore of the pair, comes in contact with the adoral pore, and then, after a course directly towards the median line, suddenly turns abactinally on the aboral shoulder of the tubercle to reach with a curve the transverse suture of the compound plate next in abactinal succession. The third plate of the triplet is a demi plate because its aboral suture, after passing actinally to the outer pore of the pair belonging to plate 2, touches the adoral pore of that pair, and thence the suture, after a short course towards the median line, turns actinally, with a curve, and reaches the transverse suture, which is placed actinally to this plate 3. The adoral and aboral shoulders of the tubercle on the compound plate are just touched by the curved sutures just mentioned.

This position of the triplet of pairs of pores is quite exceptional in the Diadematidæ.

The arrangement of the pairs and the dimensions of the triplet in the next or actinally situated compound plate are as follows:— The compound plate has no large tubercle, and it is lower than the plate above. It has two pairs of the inner row of pores, connected with its demi plates, and one pair of the outer row in association with the central or second plate, which is a primary.

Plate 1 is a low demi, of the same shape as the corresponding plate in the compound plate above, but the part of the plate toward the interradium is very low in consequence of the height of plate 2 at that part. Plate 2 is of the same shape as that already mentioned in considering the other compound plate, but the pair of pores is near the interradial edge, and so the plate is not low there. Towards the median line the plate expands, and it forms the whole of the compound plate there. Plate 3 is a demi plate, but the pair of pores is in the normal position, and is nearer the median line than the pair of plate 2.

The alternation of the position of the pairs of the demi plates and of the central primary is unexampled. The relative position of the plates is not that of *Astropyga*, and it has a kind of similitude to that seen in *Cœlopleurus*. Certainly the arrangement is generic and most distinctive.

VIII. Genus Aspidodiadema, *A. Agassiz*, 1879.

Having had the opportunity of examining specimens of *A. microtuberculatum*, A. Agass., at the British Museum, I can testify to the ability and truth of the description given by A. Agassiz of this interesting dweller in the deep ocean (Report on the 'Challenger' Echinoidea, p. 64, pl. viii. figs. 10–16).

One of the specimens is fractured, and I have been able to compare the drawing of A. Agassiz of the outside of the ambulacra with the structure on the inside of the test. There is but little difference, and, as might be expected, the adoral pore of each ambulacral plate is on the transverse suture between two of the plates. The plates are not in triplets, are narrow, and a little broader than high. Each plate is independent of that placed above and below, and in fact the ambulacra resemble those of the Cidaridæ. Of course the simple plates of *Aspidodiadema* are the analogues of the newest or last-formed plates of the Diadematidæ, close to the radial plate, and of those of the Cœlopleuridæ and Temnopleuridæ in similar positions.

DESCRIPTION OF PLATE V.

Fig. 1. *Diadema setosum*, Gray. An ambulacral compound triplet plate, seen from within, after the application of benzole. Magnified.

2. A compound plate between the ambitus and the radial plate, from within. Magnified.

3. An ambulacral compound plate near the ambitus, external view. Magnified. The sutural lines are visible after the application of benzole when the light is cast through the test.

Fig. 4. A compound plate close to the radial plate, from within. Magnified. *a*. A similar plate, lower down, seen on the outside. Magnified.

5. *Echinothrix Desori*, Agass., sp. A compound plate, four or five from the peristome; x' is the line of the auricule. Magnified.

6. The tenth compound plate from the peristome. Magnified. *a*. The same, from within.

7. A part of ambulacrum No. 1, seen from within. There are four compound plates and a part of a fifth. Magnified.

8. Some ambulacral plates near the peristome. Magnified.

9. *Astropyga radiata*, Gray. A compound plate (Plate C. of fig. 10) made up of two triplets, after benzole. Magnified.

10. Part of an ambulacrum, plates A, B, C, seen from within, showing the arrangement of the triplets and the circular depressions which correspond with the bases of the tubercles on the outside of the test. Magnified.

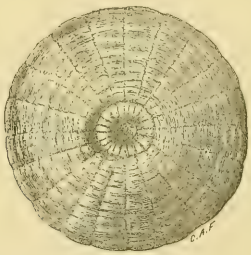
11. *Micropyga tuberculata*, Agass. Three compound triplet plates of an ambulacrum above the ambitus. External view. Magnified.

All the figures are slightly diagrammatic.

Description of a new Species of Minyad (*Minyas torpedo*) from North-west Australia. By Professor F. Jeffrey Bell, M.A., Sec. R.M.S. (Communicated by Dr. Günther, F.R.S., F.L.S.)

[Read 16th April, 1885.]

The Trustees of the British Museum have lately acquired, by purchase from Capt. Beckett, who has been sailing among the islands which lie to the north-west of Australia, an interesting example of this rare and little-known group. So little is known



Upper surface of *Minyas torpedo*, n. sp. × 2.

with regard to the Minyadidæ—the 'Challenger' even collecting but few specimens—that a short communication, though based on but a single specimen, may be of interest to the Society.

Fig 1

Fig 3

Fig. 4.a

Fig 2.

x'

Fig 5

Fig 4

Fig 7

1

2

3

4

Fig 6.a

Fig 6

Fig 8

I

II

III

IV

1

2

1

2

Fig 10

1

2

3

A

B

C

Fig 9.

1

2

3

1

2

3

Fig 11

1

2

3

1

2

3

1

2

3

E. Carter sc.

AMBULACRA OF RECENT DIADEMATIDÆ.

Mintern imp